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Canadian Society of Civil Engineers.

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TRANSACTIONS.

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THE BARRIE FLOOD OF 1890.

By WILLIS CHIPMAN, M.CAN.SOC.C.E.

The flooding of the low-lying districts of a city or town situated on the banks of a river subject to great fluctuations in level is a common occurrence. From different parts of the world, reports of the damage to property and loss of life by floods are to be seen almost continually in the newspapers. A flood in Central Africa, destroying a few thousand lives, might be read by the average citizen; a similar flood in China would be read carefully; a smaller flood in Continental Europe would be commented upon, and tender-hearted editorials would appear in the leading newspapers; while a flood causing the loss of a hundred lives in Great Britain or the United States would cause universal sympathy in the whole community, subscriptions would be solicited for the sufferers, and a commission would be appointed to investigate the causes of the disaster and recommend some scheme for preventing a recurrence thereof.

Canada is not free from floods. The St. Lawrence, the Ottawa, the Thames, the Grand, the Fraser, the Red River of the North, and other streams have at different times overflowed their banks, causing great damage to property, and frequently loss of life.

The great floods on the St. Lawrence occur above Lake St. Peter and below the Long Sault Rapids, which are immediately above Cornwall.

These floods are caused by ice jamming at some point in the river, the rise being rapid and at times unexpected. At Montreal the city is protected by dykes extending along the water front. Cornwall and Montreal have suffered at different times from floods.

Above the Rapids the St. Lawrence is subject to no greater rise and fall than Lake Ontario, the extreme fluctuation in 40 years being less than 6 feet. On the Ottawa the floods occur during the latter part of May or early in June when the melted snow from the north reaches the lower river. The rise is so gradual that sufficient warning can be given to the inhabitants of the low-lying district in the suburbs of Ottawa and Hull and the villages along the river between Ottawa and Montreal.

The Grand River in Ontario is subject to floods caused by ice jams, portions of the city of Brantford having been flooded many times, twice in 1894.

The Thames in Ontario has overflowed its banks, and a few years ago considerable damage was done at London.

The Moira and the Nation are the only other rivers in Southern Ontario that overflow their banks sufficiently to cause much damage. The Trent and the Madawaska, which are the largest rivers in the southern part of the Province, as well as the Severn and the Muskoka, which are about the same size as the Thames, cause no damage by flooding, owing to the greater part of their drainage areas being wooded and the numerous lakes within their water-sheds which constitute storage reservoirs.

Winnipeg and other towns have suffered from floods on the Red and the Assiniboine Rivers, caused by ice jams and excessive rains. In

1894, the Fraser, a mountain river in British Columbia, did a great amount of damage by overflowing its banks, caused by exceptionally heavy rains suddenly melting the accumulated snow in the mountains.

All the floods above mentioned occurred along the low banks of comparatively large rivers, and were caused generally by heavy rainfall on snow or by ice jamming at some narrow point or points in the channel, thus forming a temporary dam, the water rising until finding a new channel or until the dam gave way.

The flood that is to be described in this short paper was of an entirely different character from the foregoing.

The town of Barrie is situated on the northwest corner of Kempenfeldt Bay, an arm of Lake Simcoe, having a width of one mile opposite the main part of the town, the depth at the centre varying from 50 to 100 feet, but increasing to the eastward. The land to the north and to the south rises to a height of from 200 to 170 feet, extending to the west, forming a valley about $1\frac{1}{2}$ miles wide, which continues to the Nottawasaga River; the highest point of the valley being only 65 feet above the Bay. This valley may have been at some period in geologic time the outlet of Lake Simcoe. Around the head of the Bay are several small spring brooks, the one with the largest drainage area discharging into it near its northwest corner. During the summer months this stream is apparently smaller than some of the others to the south, but, having a larger drainage area, the flow during rains and when the snow is melting is much greater.

The total drainage area of this stream is about 1200 acres, or less than two square miles, of which about 1,000 acres or one and one-half square miles is north of and outside of the built up portion of the town, or say northeast of Peel st.; this 1,000 acres is entirely cleared farm land. The external limit of the water-shed is approximately a circle one and one-fourth miles in diameter, the rim of which has an elevation of 170 feet, that of the centre of the depression being 110 feet, and the outlet at Peel st., 61 feet above the Bay. From the point where the water course crosses Peel st., the first built up street of the town crossed by it, along the stream to its outlet, is about 5,000 feet. For more than half of this distance the bed of the stream is dry during the greater part of the year.

When Barrie was first laid out for a town, this stream flowed westerly from Peel st. to Ross st. in a tortuous channel through a swampy tract of land lying between the high terrace, a little to the north, and a remarkably narrow and high gravel ridge extending westerly from Mulcaster st. to Bayfield st. After being cleared, this low tract was a skating pond in winter and a wet marshy place in summer. When Sophia st. was laid out, the water course was straightened in such a way as to confine it north of the street, all the southerly bends being cut off and filled up. The distance from Peel st. to Ross st. is approximately 2,600 feet. For about half of this distance the bed of the stream was north of Sophia st. on private lots, and for the other half of the distance, being from Owen st. to Bayfield st., it was along the north side of the roadway. The fall in the bed of the stream from Peel st. to Ross st. was found to be 25 ft., but for half of this distance the fall was only one in two hundred.

From Ross st. the stream flowed southerly 700 feet through the town park, with a fall of 24 feet, then southerly and south-easterly, crossing Park st., Toronto st., Elizabeth st., and Mary st. to the Bay, a distance of about 1,600 feet, with a fall of 11 feet.

In grading Clapperton st. the high gravel ridge was cut through and removed to the full width of the street. Immediately west of Owen st., the ridge was also removed on several town lots. In 1846 the stream overflowed its banks, and ran down Clapperton st., washing out a channel which was not filled in for several years.

In 1860 another overflow took place, after which the channel was straightened along Sophia st., and the roadway raised to form an embankment about three feet high above the bed of the stream. About 1870 a timber drain 3 feet wide inside and 4 feet high was built from

the bay to Sophia st. along Clapperton, the idea being to relieve the stream in time of freshets. The northerly portion of this drain collapsed in 1886, and was replaced by an 18 inch tile pipe for 500 feet.

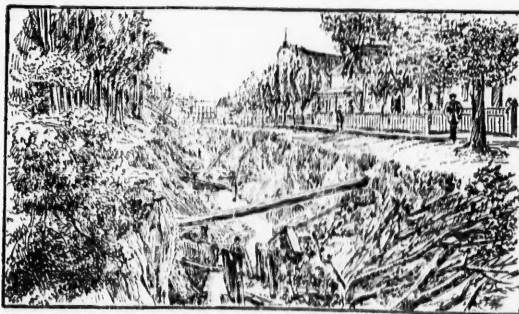
The top and sides of this drain were of three inch planking laid longitudinally and spiked to bents placed $3\frac{1}{2}$ ft. centres. The bottom of the drain was of two inch planking. Each bent was built of four pieces of timber top and bottom $5'' \times 8''$, verticals $5'' \times 8''$, joints halved and spiked. The planking was out-side of the bents. There was no way of inspecting this old drain except by walking up it from its outlet. When the stream at its head raised to about half the height of the Sophia st. roadway, a portion of the water discharged through the 18 inch pipe into the old drain.

The following culverts were constructed in the town along the course of the stream:—

No. Culvert.	Length. Feet.	Width. Feet.	Height. Feet.	
1 Berczy St.	14 (?)	$5\frac{1}{2}$	3	
2 Peel St.	20 (?)	(?)	5 (?)	
3 Private	165	8	5	
4 Owen,	16 (?)	(?)	5	
5 Clapperton,	(?)	(?)	5 (?)	
6 Bayfield,	66	$6\frac{1}{2}$	5	
7 W. of Bayfield, Private,	280	$4\frac{1}{2}$	4	Continuation of Bayfield Culvert, irregular and obstructed.
8 John,	30	3	3	
9 Mary, N.	14	$5\frac{1}{2}$	3	
10 Ross,	78	6	3	Not straight.
11 In Park,	32	$5\frac{1}{2}$	6	
12 Park,	47	6	$3\frac{1}{2}$	
13 N. W. of Toronto, Private,	153	9 to 12	3 to 2	Not straight.
14 Toronto St.	80	4	5	Obstructed by cross braces.
15 S. E. of Toronto, Private,	123	7 to 12	3 to 2	Irregular.
16 Elizabeth,	70	6	3	Obstructed by cross braces.
17 Mary, S.	153	4	3	Irregular and crooked.
18 G. T. R.	20	6	3	

All those street culverts and culverts on private property were of wood, generally with sides of square timbers laid horizontally, rag-bolted together or anchored back at intervals in height to resist side pressure, or occasionally braced across inside. All were covered with timber or planking. Some few of them were built of round timber in whole or in part.

Culverts 1, 4, 5 and 9, as above numbered, were unimportant, and might be called temporary structures. Between Owen st. and Bayfield st. there were also two or three private crossings of plank on sribners over the stream for entrance to cottages on the north side of the street.



Culverts 1, 2, 4, 5 and 9 were completely destroyed by the flood, and many others were so damaged that it was necessary to remove the remaining parts in order to rebuild them.

With no town engineer to advise the town authorities, and with immunity from damage from flood for 30 years, the water course had

been neglected, the street culverts had not been cleared out thoroughly, the open channel or ditch along the north side of Sophia st. had become a dumping ground for old tinware, old boots, etc., while the Council had permitted parties to cover the stream on private lots, culverts 3, 7, 13, 15 and part of 17 being on private property.

These private culverts were not inspected when built or afterwards; they were irregular in size, crooked in alignment and in shape, and were not repaired or cleaned out except as each owner or tenant might please. Floating boards, timbers, blocks, brushwood, grass, etc., became lodged in the bends and irregularities in the private culverts, at points where they could not be seen.

During the first week in June, 1890, the corporation labourers were repairing some break in the old timber drain on Clapperton st., and had an opening made in the street near Worsley st. for this purpose.

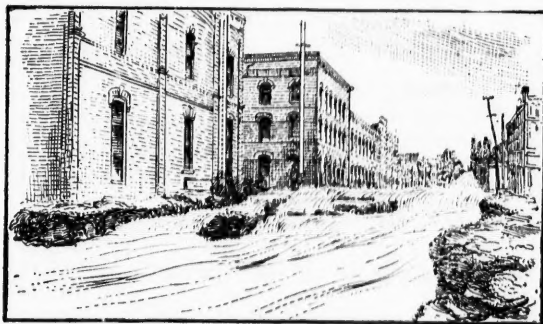
On Thursday, June 5th, 1890, the day of the Provincial Elections, an unprecedented fall of rain occurred in the vicinity of Barrie as well as in different portions of the central parts of the Province of Ontario. The heavy rain was not uniformly distributed, as in some places, not five miles from Barrie, there was no rain to speak of. The downpour commenced about 2 o'clock in the afternoon of the 5th, increasing in intensity until 3 o'clock. The rain was accompanied by heavy thunder and lightning, and the town was in almost total darkness during the heaviest showers.

At 2.15 a pond of water had formed northeast of Peel st., reported as covering about 10 acres.

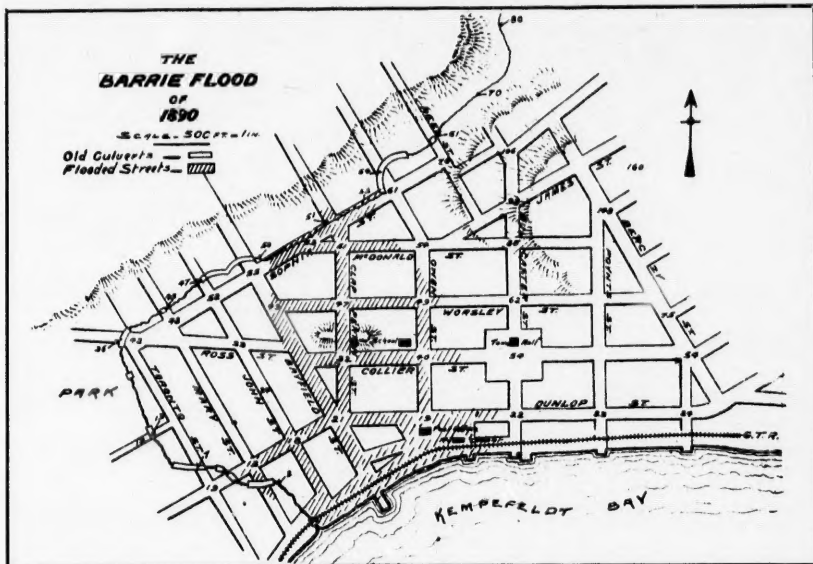
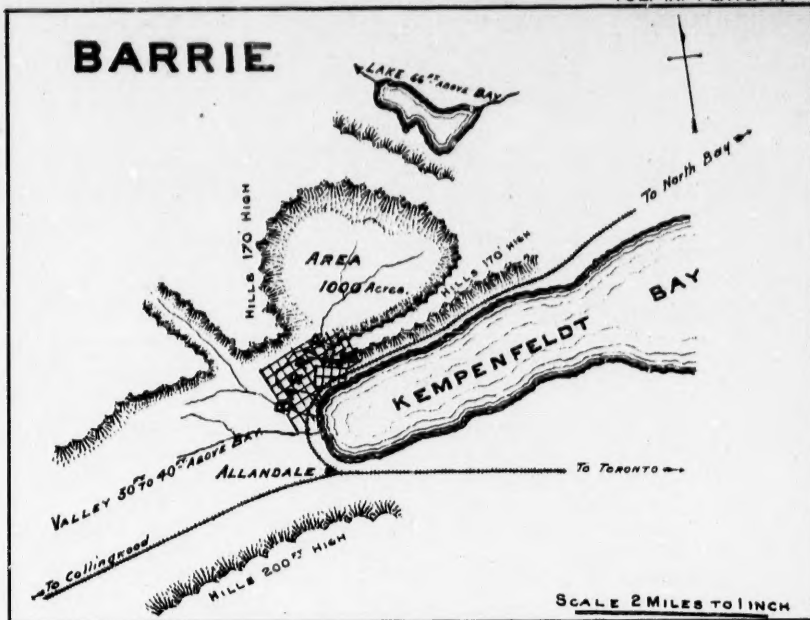
This pond could not have been more than 500 feet in length, about 150 feet in width at Peel st., and about 6 feet deep at its deepest point. From these dimensions it is evident that the pond could not have covered 10 acres, but it may have covered three, and the average depth could not have been more than two feet.

It is more than probable that the Peel st. culvert became blocked, as the water rose nearly or quite to the surface of the roadway. The roadway broke away about 2.20 p.m., and it is probable that the channel of the stream below this was about filled by this time by the drainage from Sophia st. and the lands to the north of it.

About 2.30 the stream overflowed Sophia st., for nearly the total distance between Owen st. and Bayfield st., some 1,000 feet, filling cellars and basements and invading the floors of dwellings, the Central Public School, and the business portion of the town on both sides of Dunlop st. from west of Bayfield st. to east of Owen st., a total distance of about 1,300 feet. The post office and railway station were surrounded by the flood, the water rising above the ground floor of the latter.



The flood down Clapperton st. entered the old box drain at the point where the workmen were repairing it, and in a few minutes a torrent was rushing through it. The street was washed out in places from curb to curb from Worsley st. to the bay, the depth at Worsley st. being 16 feet.



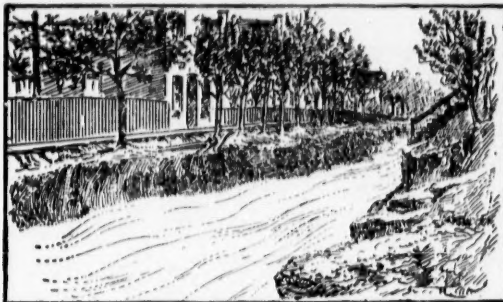
tracks and carried into the bay. Cars were shifted on the tracks by the floods, the tracks undermined, and traffic suspended for some time.

Great difficulty was met with in securing satisfactory detailed descriptions of the flood on Clapperton st., as all who witnessed it were too interested in their personal safety, or in the saving of life and property, to make many observations of scientific value. The reports of the time at which the flood first rushed down the street and the time it ceased, as given by eye-witnesses, varied most unaccountably, and the reports in the newspapers were of little value except in itemizing the damages done.



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The detached residences and the fences along the south side of Sophia st. so obstructed the current that the greatest flow was along the streets.



Upon reference to the plan, it will be seen that Clapperton st. is 2 or 3 feet lower than Owen to the east or Bayfield to the west, also that the fall from north to south is much greater than at right angles. The gravel ridge before mentioned formed wing walls to concentrate the flow down Clapperton below Worsley. The streams down Bayfield and Owen also did some damage by filling basements and cellars, and by entering on the ground floor of the Public School. The ground floor of this building at the rear is but little above the ground level, but at the front there are several steps from the ground to the floor. The street in front is 40 feet above the Bay and only 800 feet distant, therefore, the inclination being 1 in 20, and uniform.

It is not surprising that a panic ensued among the children and teachers. The darkness, the lightning and the sudden inrush of a torrent of water at that height above the bay would be sufficient to make any heart quail.

The children were rescued by the fire department with some difficulty, as the velocity of the current was such that the smaller children could not in their frightened condition make headway against it.

On Clapperton st. below Worsley the greatest damage was done. The old box drain collapsed, was washed out or filled up. For several hundred feet it was not only destroyed, but nearly every trace of it was removed, and the debris washed into the bay. The depth excavated by the torrent at Worsley st. was about 16 feet, decreasing to 7 feet at Collier and 4 feet at Dunlop.

From Sophia to Collier the height of the water did not exceed one foot above the surface of the ground, but at Dunlop st. the flood mark was fully 3 feet above the sidewalk.

From Sophia st. to Worsley st. the surface inclination of Clapperton is 1 in 100; Worsley to Collier 1 in 25; Collier to Dunlop 1 in 50 and below; Dunlop about 1 in 50.

A stream of water a foot deep, 66 feet wide, and flowing down an incline of 1 in fifty, would be considered a large stream. Clapperton st. proper ends at Dunlop, meeting Bayfield at one acute angle. The force of the stream struck the west side of Bayfield below Dunlop, completely demolishing one rough east house, from which the occupants barely escaped with their lives. The total quantity of earth removed from Clapperton st. after the flood was approximately 7,000 cubic yards. The earth, timbers and debris were deposited along the railway tracks and carried into the bay. Cars were shifted on the tracks by the floods, the tracks undermined, and traffic suspended for some time.

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The following facts are, however, to be relied upon:

1. The rain began early in the afternoon, the heavy rain beginning at 2 o'clock.
2. The pond above Peel st. broke away between 2.15 p.m. and 2.30 p.m.
3. The culverts between Bayfield and John became blocked, causing the stream to overflow Sophia st. about 2.30 p.m.
4. Very heavy rain continued until 3 p.m., the heaviest downpour occurring at this time.
5. The greatest flow down the street was about 4 o'clock.
6. The creek continued to overflow its banks on Sophia st. until 5 p.m., if not longer.
7. Dunlop st. and Collier st. were flooded from Clapperton to Owen for two hours.
8. The pond formed above Peel st. had an area of about 3 acres, with a maximum depth of 6 feet.
9. The water course was practically dry at noon on the day of the flood.

As previously stated, the drainage area of the stream does not exceed 1,000 acres above Peel. The average slope of the surface of the ground in this area towards the lowest point is 1 in 50.

The following is the reputed rainfall for the 3rd, 4th, 5th and 6th June, as given by the Head Master of the Collegiate Institute, who had for many years acted as observer for the Meteorological Department:—

	Tue. 3rd.	Wed. 4th.	Thur. 5th.	Fri. 6th.
Temperature, Max.	98			
Min.			62	
Rainfall, inches	0.54	1.24	2.90	0.05
" duration	2 hrs	6 hrs	5 hrs	½ hr

In 4 days, rain fell to the depth of 4.73 inches.

The observations were taken at a point about three-fourths of a mile easterly from the town hall, the observer being furnished with an ordinary surface rain gauge.

The rainfall, as reported by a corporation employee, was much greater than this, and his statements were corroborated by other witnesses.

Wednesday afternoon and night $2\frac{1}{2}$ inches of rain fell.

Thursday, 5th June.	{	1.45 p.m. to 2.15 p.m.	$4\frac{1}{8}$ "
	{	2.15 " " 3.45 "	0"
	{	2.45 " " 3.15 "	$4\frac{3}{4}$ "

The rainfall as above given was determined by measuring the depth collected in open vessels, barrels, pans, etc. These observations were made in the town within or near the flooded district.

It is probable that between $1\frac{1}{2}$ and 2 inches of rain fell during Wednesday and Wednesday night, and that during the afternoon of Thursday the rainfall was between 3 inches and 6 inches over the drainage area of the stream that caused the flood.

Three miles south of Barrie, ten miles north of Barrie, and 15 miles east of Barrie there was but little rain on Thursday.

The distance from the centre of the drainage area of the stream to Clapperton st. is approximately 4,000 feet, the fall being over 50 feet or an average inclination of one in eighty, the water course being very crooked above Peel st. and obstructed by vegetation. The velocity of the stream was not observed, but it was probably not less than 2 feet or more than 5 feet per second.

Assuming that the maximum rate of rainfall was 4 inches per hour, and that the ground was fully saturated by the rainfall of the day and night preceding, the run-off can be approximately determined.

By different formulæ it will be found to be between 1,000 and 2,000 cubic feet per second.

Assuming that the water course below Bayfield was sufficient to carry the water that fell on the tributary drainage area below Peel st., it is probable that one-half of the overflow passed down Clapperton st., probably about 750 cubic feet per section.

In a stream 60 feet wide and one foot deep this would give a velocity of twelve and one-half feet per second.

It is impossible from the observations made and data obtainable to determine the actual maximum overflow that passed down Clapperton st., but, in the writer's opinion, it was much greater than the amount above given.

During the flood this street from Worsley to Dunlop had the appearance of a tempestuous rapid, the waves being several feet in height. The velocity was not determined by observations.

The depth of the stream and the form of the channel varied from place to place, and was continually changing from the erosion.

If we take the total rainfall as $4\frac{1}{2}$ inches in $1\frac{1}{2}$ hours, and assume that it all ran off in $2\frac{1}{2}$ hours, this will give an average run off of about 2,700 cubic feet per second, and probably double this as a maximum, allowing nothing for evaporation, absorption or other loss.

The writer was engaged to report upon the best means of repairing the damage done to the streets, and the works necessary to prevent a re-occurrence of the disaster.

The works consisted in :

1. Laying a sewer to the full length of Clapperton st., and then re-filling the street.
2. Straightening and enlarging the channel of the stream below Peel and diverting it from private property when possible.
3. Raising the roadway on Sophia st.
4. Constructing culverts of uniform cross-section straight from end to end, and all built to grade.